MiQ 45V Comments - Summary

MiQ has established the following comments in the current 45V rule, published Dec 26, 2023, with regards to the use of national averages as background data for natural gas upstream methane loss rates, as well as the readiness of verification mechanisms that could be utilized for certain background data in 45VH2–GREET.

- ***The use of a national average for GREET inputs results in an underestimation of methane emissions:*** Due to the wide distribution of methane loss inputs that exist in the current natural gas market, use of a national or regional average is problematic and poses a very high risk of underestimating hydrogen's carbon footprint**.**
- ***Allowance of bespoke, measurement-informed GREET inputs will create incentives to dramatically reduce upstream methane emissions:*** Demand-side pressure can lead to significant and speedy emission reductions when applying credible principles, such as the use of asset-level verification of methane and total GHG emissions.
- ***Credible, high-fidelity data is currently available:*** The use of high-fidelity, measurement-informed and independently verifiable emissions data is currently being put into practice through the MiQ Certification program, which now certifies over 20% of US production and has been operational for 3+ years. Other reporting programs such as UNEP's OGMP 2.0 are driving more operators to develop asset-level measurement-informed methane emissions inventories within this decade.
- ***Determining measurement-informed methane emission data on a producer-by-producer basis is cost-effective:*** Credible and verifiable methane emissions data can be readily and credibly obtained from all participating natural gas supply chain segments, while the costs to achieve verification are easily offset by the 45V tax credit

We present the following implementation recommendations to allow the use of bespoke inputs for natural gas methane loss towards the calculation of a carbon footprint of clean hydrogen.

To enable the use of bespoke emissions data for natural gas as foreground inputs into GREET, the U.S. Treasury, supported by the DOE and EPA, should officially accredit or recognize those (a) metrics/standards, (b) verification programs, and (c)certificate registries that meet the criteria for a credible and verifiable differentiated natural gas market. The DOE, namely the FECM, has unique experience and familiarity with the methane issues from the natural gas sector and poised to implement such accreditations. There is a pre-existing model in the United States for this as the same has already been done for REC registries. These criteria must include:

- *The use of a* ***measurement-informed emissions reporting standard****. Such a standard (or metric) must:*
  - *Recognize top-down and bottom-up measurement-informed evaluation of emissions. This means that data from the source level (bottom up) and facility or asset level (top down) must be considered or reconciled in the accounting of total emissions. Examples of such standards include the OGMP 2.0 protocols, GTI Veritas protocols, and the MIQ Performance Standard.*
  - *Represent a complete assessment of all emissions sources, all technologies, and all gas flow from an entire asset or facility (meaning all contiguous, commonly owned and operated equipment, not only a subset of equipment or wellpads or data based on pilot studies) to avoid cherry picking emissions.*
- *The application of verification protocols which match 45V requirements, including:*

    - *The verifier is unconflicted to the data, therefore has no financial interest in the outcome of report*
    - *The verifier is a subject matter expert and technically accredited to the standard they are verifying against*
    - *The verifier is independent of the data collected.*
- *The use of registries that provide services and information sufficient to issue, track, move, and ultimately retire certificates and their corresponding environmental attributes to prevent double counting, consistent with the 45V requirements for EACs. Such registries and certificates must include:*
    - *Unique identifier numbers for each unit of energy*
    - *Details on the geographical provenance, facility name, and operator responsible for the verified emissions intensity*
    - *Details on the supply chain segment sufficient to construct a supply chain intensity*
    - *Time stamps for each unit of energy throughput*
    - *Details of the third-party verifiers for each facility*
    - *Details of verified emissions intensities sufficient to support hydrogen producer verifiers to cross reference for inputs into carbon footprint calculations.*
    - *Retirement statements that can be used as credible and direct evidence for foreground inputs into GREET 45V and verified by a hydrogen production verifier.*

1. INTRODUCTION

MiQ is a non-profit organization, developed out of the Rocky Mountain Institute and Systemiq in 2019, designed to independently grade methane emissions performance for the natural gas supply chain, certify emissions through an independent verification program, and generate certificates on the MiQ Registry as documentation and tracing of well-to-gate emissions for each MMBtu of gas throughput. MiQ's theory of change is that the differentiation of all natural gas based on methane emissions will enable the market to selectively procure and demand lower emissions from the upstream sector, thereby providing additional levers in the race to eliminate methane emissions from the natural gas supply chain. The Treasury Department has **sought comment on the readiness of verification mechanisms that could be utilized for certain background data in 45VH2–GREET if it were reverted to foreground data in future releases.** The following text will demonstrate the readiness and credibility of verification mechanisms, currently in place, to support this need.

2. BACKGROUND ON THE IMPACT OF METHANE

2.1. Methane Global Warming Impact

Methane is a unique greenhouse gas, known as a short-term climate pollutant, which blankets the earth with enhanced warming in the near term, thus having a more immediate impact on damaging climate change outcomes such as sea level rise, storm severity and wildfires. Methane has a global warming potential of 120x that of CO2 out of the wellhead, 82x over 20 years, and 29x over 100 years[1]. MiQ stands behind the use of a carbon footprint to differentiate all energy, and that this term must use a CO2-equivalent based on an aggregate sum of greenhouse gases. However, when it comes to levers that address the abatement of greenhouse gases, where possible, we must specifically treat fugitive methane as the "bleeding artery" to reach our climate goals ahead of 2030. This directive is consistent with the directives under the Inflation Reduction Act.

2.2. If Natural gas is to play a role in hydrogen production, it should be held to the same high standard for carbon accounting as other renewable fuels.

Natural gas and its infrastructure will inevitably serve a role during the energy transition. For example, hydrogen blending, and renewable natural gas require the use of existing pipeline infrastructure to transport fuel throughout the country. In addition, natural gas coupled with carbon sequestration is a necessary feedstock for gas-based hydrogen (and its derivatives such as blue and turquoise ammonia) used domestically, as well as overseas where affordable renewable energy and CCS may not be an option. Methane emissions accounting and reduction for natural gas is the focus of numerous federal projects, such as the EPA Methane Star program which backs One Future; the DOE has set up a task force to create an MMRV in recognizing the importance of accounting for methane emissions in LNG exports especially in light of the EU methane rules; the Inflation Reduction Act has focused a considerable amount of its attention on methane. Accounting for the full well-to-gate emissions profile of hydrogen means recognizing the same risks and need for

[1] Masson-Delmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, ... B. Zhou (2021). Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press.

credible and granular carbon accounting when it comes to methane emissions as the natural gas fossil alternative that it will be competing against and ultimately replacing.

3. IMPACT OF METHANE LOSS ON H_2 CARBON FOOTPRINT

3.1. National, or even basin-wide, averages for natural gas methane emissions are problematic because they exhibit such a broad distribution.

Methane inventories, due to the stochastic and unintended nature of how most major emissions are generated, have an incredibly broad distribution - at both the source and operator levels. This means that an operator with a large amount of unintended emissions may emit 10x the methane of highly compliant operators with minimal process and operational failures.

Top-down measurement studies conducted by Kairos[2] across the Permian basin, published as part of their Basinwide Index efforts, illustrate that the 75 most productive operators emit between 0.5% and >5% methane loss for the production segment alone (as allocated to the natural supply chain using the NGSI methane intensity calculations), **Figure 1**. This is in stark contrast to bottom-up inventories using generic emissions factors which do not differentiate operators based on unique unintended emissions. For example, the GHGRP distribution from the Permian Basin published by ERM[3] results in a comparatively flat and lower loss rate distributions, **Figure 2**. This means that even with improved reporting requirements by the EPA (i.e., updated EPA GHGRP Subpart W reporting) and more representative source-level emission factors, we are unlikely to resolve the realistic emission distributions presented by individual operators with differing operating conditions. Actual differences can only be demonstrated through facility-scale, measurement-informed studies.

Natural gas methane emissions from the rest of the supply chain segments (gathering, processing, transmission) are also differentiated based on the type of geographical basin from which they operate. These may or may not include co-produced liquids, and will differ in the amount of acid gas removal required and the pressure in the subsurface from which it originates, and the distance traveled requiring considerable compression to meet its final destination.

Basin-wide averages may seem like a creative and meaningful compromise for use in the GREET model, however the same extreme distribution of emissions by operators is also found at the basin level. As a result, the potential for a carbon footprint to contain well-to-gate emissions which far exceeds the threshold for 45V is just as likely as when using a national average. Furthermore, basin-wide averages divorce the ability for operators to carry out actual reductions which should be a necessary component in demand-side instruments like the 45V tax credit. Gas from certain basins, such as the Permian basin, could have the greatest opportunity to reduce emissions overall.

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[2] https://www.basinwide.org/index

[3] ERM, Benchmarking Methane and Other GHG Emissions of Oil and Natural Gas Production in the United States, May 2023, retrieved from https://www.sustainability.com/contentassets/95c6e3e4c9a440049e3533575d0b389e/oilandgas_benchmarkingreport_2023.pdf

Unfortunately, the use of a basin-wide average may outright disqualify Permian gas as eligible for use under 45V, thereby eliminating any incentive for a Permian operator, with arguably the greatest opportunity for impact, to reduce their emissions as a result of this program. Lastly, hydrogen production using gas from an oil-producing basin with higher average emissions will more likely ignore the 45V credit opportunity if no incentive to reduce and verify emissions exist, and default to the 45Q credit where no acknowledgement or penalty for the impact of methane emissions is taken into account.

Methane emissions cannot be treated like any other combustion-related emissions, nor can they be painted with a single national average without risk of extreme unrepresentativeness and uncertainty.

3.2. GREET national averages drastically underestimate methane loss compared to up-to-date, empirically derived studies.

In the past decade, only a handful of nationwide studies of nation-wide (or regional) methane emission baselines have been conducted. Alvarez et al (2018), applying over 500 measurements, suggests that the national supply chain methane emissions, as reallocated here to the natural gas product, are 0.9% methane loss for the production sector, and 1.9% overall including boosting and gathering, processing and transmission. Sherwin et al (2023)[4], conducted top-down remote sensing surveys and bottom-up models across six complete oil-rich and gas-rich basins. This study indicates that basin-specific methane loss averages can range from 0.64% to 4.7% (as re-allocated to the natural gas product) for the production sector alone, depending on the basin location and time of year. Midstream (gathering, boosting, processing and transmission combined) methane loss exhibits a similarly broad distribution of a 0.33% to 2.38% (as re-allocated to the natural gas product) across the basins studied. MiQ and Highwood extrapolated the results of Sherwin et al (2023) applying over 300,000 measurements into a nation-wide average[5], which resolved an estimated 1.0% methane loss from the production segment and 2.2% methane loss across the entire natural gas supply chain

The GREET background data stands in sharp contrast to these measurement-informed studies. Utilizing the GREET background data put forth in the proposed rulemaking, methane loss is estimated as 0.36% for the production segment, and 0.85% for the complete natural gas supply chain, less distribution, as shown in **Figure 3**. Compared to the informed studies by Alvarez (2018) and the MiQ-Highwood Index applying over 300,000 measurements (based on Sherwin et al (2023)) which suggest over 2x the emissions than currently assumed by the GREET model. As noted in the

[4] Sherwin, Evan, Jeffrey Rutherford, Zhan Zhang, Yuanlei Chen, Erin Wetherley, Petr Yakovlev, Elena Berman et al. "Quantifying oil and natural gas system emissions using one million aerial site measurements." (2023)

[5] Rutherford, J., Romo, J., Fox, T., Owens, L., The MiQ-Highwood Index : A national-scale measurement informed methane intensity for the United States (2023), retrieved from https://miq.org/wp-content/uploads/2023/06/MiQ-Highwood-Index.pdf

GREET 2023 45v Operating Manual[6], the DOE is currently attempting to improve our understanding of emissions from several basins and across the United States, to be funded by the Inflation Reduction Act. The current EPA GHGRP program has also attempted to improve reporting capabilities to rectify previous undercounting and better match to top-down estimates. These efforts, unfortunately, will take 3-4 years to produce usable or meaningful results for refined GREET inputs, which will stymie current efforts to generate low carbon hydrogen through this tax credit. In addition, there are no statutory or regulatory requirements that updated GHGRP numbers be integrated into refined GREET inputs. Lastly, the uncertainty generated by unknown yearly updates would generate an inability for hydrogen producers to secure the necessary investments to generate hydrogen under this tax credit.

Currently, credible and verifiable emissions accounting mechanisms exist for determining asset-level[7] emissions data for the natural gas supply chain, as we will demonstrate below. Given the large uncertainty and risk of undercounting when using national averages for natural gas methane loss, allowing project-specific foreground inputs for the GREET model is the most viable solution for resolving an accurate and meaningful carbon footprint for gas-based hydrogen.

3.3. Realistic methane emission inputs suggest broad distribution of H_2 carbon footprints using the GREET model.

As shown in **Figure 4,** below, (Scenario A) hydrogen produced by SMR with 95% carbon capture and sequestration, may still be eligible for the 45V tax credit when applying the GREET methane loss default factor, with a resulting carbon footprint <4.0 $kgCO2e/kgH_2$[8]. However, if we assume a more realistic methane loss of 2.2% (Scenario B) according the results of Sherwin et al (2023), or a feasible 4% methane loss (Scenario C) from an oil-producing basin such as the Permian, even with optimistic 99% carbon capture, we resolve carbon footprints well in excess of 4.0 $kgCO2e/kgH_2$, thus disqualifying the projects for the 45v tax credit. The unintended consequences of imposing a national average methane loss, even if more realistic than that used by the current GREET model, is that hydrogen and ammonia producers may opt for the 45Q credit where absolutely no accountability for methane usage is taken into account.

The implications of this are clear and negative – in the absence of bespoke, measurement-informed facility-level GREET inputs, the value of 45V as a tool to incentivize emissions reductions will be

[6] USDOE, Guidelines to Determine Well-to-Gate Greenhouse Gas (GHG) Emissions of Hydrogen Production Pathways using 45VH2-GREET 2023 (2023), retrieved from https://www.energy.gov/sites/default/files/2023-12/greet-manual_2023-12-20.pdf

[7] "Asset-level" defined here at the Unit Process level for an LCA, and necessary to avoid cherry picking emissions result. For a natural gas supply chain segment, this "asset-level" represents all contiguous emissions generating equipment commonly owned, operated and managed within a geologic basin or sub-basin. Here, "asset-level" is consistent with "facility" – as defined in the United States Environmental Protection Agency in CFR Title 40, Chapter I, Subchapter C, Part 98, Subpart W, Section 98.238 and includes all onshore petroleum and natural gas production equipment associated with all wells that the person or entity owns or operates in a basin.

[8] Carbon footprints calculated under the GREET model apply the 100year GWP (IPCC AR5) for methane of 28x that of CO2.

negated. Utilizing national averages will simply push producers to the 45Q credit – resulting in no incentive at all to decrease their upstream methane emissions.

We can also apply realistic methane loss estimates from low methane emitting basins and supply chain segments operating today. Table 1 illustrates realistic methane loss estimates from producers or operators currently undergoing verification of their emissions under the MiQ Program. Scenario D in **Figure 4** represents among the most optimistic case of 99% carbon capture by SMR and MiQ A-grade natural gas fuel and feedstock with an estimated methane loss of 0.18% from across the natural gas supply chain, resolving a carbon footprint of 2.63 $kgCO_2e/kgH_2$. Applying additional levers to Scenario D, such as use of renewable natural gas, could tip this project below 2.5 $kgCO_2e/kgH_2$ or even 1.5 $kgCO_2e/kgH_2$ and be eligible for greater tax incentives. This highlights the value of a) allowing bespoke, measurement-informed, asset-level GREET inputs, as b) a function of the incentive utility of 45V.

Scenario F exemplifies a realistic hydrogen project whereby carbon capture efficiency must be improved and refined over time. Allowing for sourcing of low emission natural gas (MiQ A grade) until the time that maximum carbon capture can be attained, allows flexibility for a long-term project experiencing downtime and process refinement with regards to its carbon capture. Lastly, Scenario E applies an average verified methane loss of ~0.5% from Table 1 and illustrates realistic sourcing potential for current projects which may resolve a carbon footprint of <4.0$kgCO_2e/kgH_2$.

4. BESPOKE METHANE EMISSION INPUTS FOR GAS-BASED HYDROGEN WILL HELP DRIVE DOWN ACTUAL EMISSIONS ACROSS THE US.

4.1. Bespoke emission inputs create demand side levers for emission reductions.

The use of bespoke user inputs for methane loss addresses 45V's objectives to create new and genuinely clean hydrogen. The use of taxpayer dollars to incentivize clean hydrogen production requires nothing less than actual well-to-gate carbon footprints based on actual verified inputs. Without access to verifiable methane losses as bespoke inputs in the calculation of a carbon footprint, hydrogen operators may be perversely incentivized to use the 45Q tax credit to generate gas-based hydrogen which has no visibility or accountability with regards to natural gas impact on hydrogen footprints at all.

Verified methane loss rates for natural gas supports buyer decisions and can create market thresholds with high standards regarding methane emission loss. One might wonder if the volume of low methane loss natural gas necessary to support the development of clean hydrogen production will be enough to stress upstream suppliers into verifying and/or reducing their emissions. The answer is yes. 45V is only one out of several end-use markets for low emissions natural gas, potentially with equally ambitious thresholds to limit access to natural gas with high methane losses. When all of these demand side levers are pulled, they can drive additional pressure on upstream natural gas operations to reduce emissions faster, above and beyond what regulatory measures can achieve alone.

4.2 Without bespoke emission inputs, Hydrogen Producers will move towards 45Q where no acknowledgement of the impact of methane emissions is considered or disincentivized.

It is clear the tax incentives for gas-pathway hydrogen production with carbon capture are comparable between 45V and 45Q. Many hydrogen operators have indicated in one-on-one discussions, that without the opportunity for bespoke inputs for methane production they will be perversely incentivized to use the 45Q tax credit, even if the cost to tax payers would have been equal. Without the structure and accountability of 45V's rule which aligns behind accurate emissions accounting and determination of a carbon footprint, it will be impossible for the administration or agency to track the environmental impact of new clean hydrogen production generated through the IRA.

4.3 The key to achieving *actual* demand-driven emission reductions is the integration of credible principles into the market for natural gas differentiated based on its methane emissions.

- **Principle 1 – Use of measurement-informed, reproducible standards.** As discussed below, such standards currently exist and are being applied by operators today. These publicly accessible standards must be used to determine measurement-informed emissions data that can be used for bespoke GREET inputs.
- **Principle 2 –Methane emissions must be resolved at the basin or asset level.** Not only is this definition consistent with the 45V and EPA SubW's definition of "facility" (meaning all equipment encompassed in the production of said product), but it also meets the correct granularity associated with life cycle assessments. For a natural gas operator, cherry-picking production from only new or low emitting equipment does not represent the true impact of emissions from the larger asset and can artificially reward practices that are by nature lower emitting. In this instance, 'cherry-picking' is characterized as verifying the emissions of only a subset of wellpads or equipment in a facility.
- **Principle 3 – Methane emissions must be verified by an independent third-party auditor.** As described here, understanding the source of methane emissions goes beyond a simple accounting exercise and must evaluate the risk of operational upsets or abnormal process conditions, which are typically responsible for unintended emissions exceeding a typical inventory. Proper verification of methane emissions requires evaluation of a company's operations and safeguards (such as monitoring practices and procedures) to ensure mitigation and proper quantification of unintended emissions. To achieve necessary credibility, this must be conducted by an independent subject matter expert with no ties, input, or conflict to the outcome of the audit.
- **Principle 4 – Use of robust registries to allow proper tracking and retirement to avoid double counting of methane emission attributes**. As described below, a credible registry mechanism, following the criteria set forward for EAC programs, is necessary when subscribing unique, or bespoke, inputs to models such as GREET.

5. UPSTREAM EMISSIONS ARE AVAILABLE TODAY WITH HIGH FIDELITY AND ARE INDEPENDENTLY VERIFIED.

5.1. Verifiable methane emissions data requires credible, measurement-informed standards

Minimum requirements for any reliable technical quantification methodology must include: (1) measurement-focused inputs that recognize top-down and bottom-up evaluation of emissions; and (2) assessment of all emissions sources and all gas flow from an entire facility. The MiQ Methane

Performance Standard[9] is one such protocol and has been used in practice for over three years. Other such protocols currently exist[10] [11] or may arise; however, the key is that any quantification methodology protocol is (3) applied at the asset or "facility" level, and (4) coupled with third party assessment to ensure the criteria are met with the highest fidelity and not obfuscated or gamed.

The MiQ Standard meets these requirements applying the following procedures:

Step 1 – **Deployment of top-down and bottom-up monitoring technologies**

All leaks and unintended emissions identified during source level and facility level campaigns must be recorded and quantified. Detection capabilities and quantification (measurement) capabilities for all technologies must be verified against the MiQ Standard's requirements for controlled release testing and adherence to proper deployment. The more frequent the monitoring campaign, the lower the minimum detection limit (MDL), the higher confidence level in the final calculated emissions intensity awarded by the MiQ Standard.

Step 2 – **Deployment of best practices**, including use of operator AVO and LDAR training, SOPs for handling methane, detailed analysis of methane leaks and sources to direct LDAR and Maintenance & Repair activities, company methane KPIs, equipment upgrades to "engineer-out" sources.

Assurance of best practices minimizes the occurrence of unintended emissions exceeding emission factors. The greater the compliance with best practices, the higher confidence level in the final calculated emissions intensity awarded by the MiQ Standard.

Step 3 – **Reconciled accounting of both bottom-up inventories and top-down facility scale monitoring campaign data**.

Bottom-up inventories include all sources found in EPA SubW (including equipment leaks) plus additional sources not found in SubW and all those identified during top-down monitoring campaigns. Facility specific measurements for individual sources must be verified against the MiQ Standard's requirements for controlled release testing and adherence to proper deployment. Top-down inventories must include quantification (measurement) of all unintended emissions (from Step 1) along with a duration estimate based on continuous monitoring data or other SCADA. The more frequent and lower MDL of each monitoring campaign, the more detections that are found, the higher confidence level in the reconciled emissions intensity awarded by the MiQ Standard

The MiQ Standard for methane emissions performance and GHG accounting was constructed using non-profit funds, applying extensive stakeholder feedback, built upon the ISEAL principles[12], the

[9] https://miq.org/document/miq-standard-onshore/
[10] https://ogmpartnership.com/
[11] https://www.gti.energy/veritas-a-gti-methane-emissions-measurement-and-verification-initiative/
[12] ISEAL Alliance. (2013). ISEAL Credibility Principles: Principles for Credible and Effective Sustainability Standards Systems. Retrieved from https://www.isealalliance.org/defining-crediblepractice/iseal-credibility-principles

Methane Guiding Principles[13], the API compendium[14], and is compliant with ISO 14064/5 and the GHG Protocol.

Several methane accounting standards currently can support the requirements for a measurement-informed assessment of methane loss from any segment of the natural gas supply chain. The reporting Standard alone, however, cannot assure a complete or accurate assessment of methane loss. This is due to the multiple points of verification necessary to determine adherence to the accounting procedures, review of the thousands of data points and equipment counts for any given facility, the honest and sophisticated use of monitoring and measurement technologies, the determination of intended vs unintended emissions in an inventory, as well as compliance to best practices to minimize the occurrence of abnormal operating conditions which greatly impact inventories.

Independent non-profit frameworks with detailed third-party verification requirements, like MiQ's, exist to oversee and assure that these criteria are adhered to.

5.2 Emissions data require robust verification processes using accredited third-party auditors, consistent with 45V's requirements for verification

Current certification programs, such as MiQ's, apply a robust verification process whereby both methane and total GHGs (CO2 and N2O) are evaluated at the Reasonable Assurance[15] level. MiQ has been in practice for over three years. Operators submit emissions data, as well as operating SOPs, training documents, evidence of completion of emission monitoring surveys, results of measurement studies, controlled release testing results of any measurement equipment applied as well as how they were deployed. Operators are observed and interviewed in the field as to their handling of methane and operating equipment, how monitoring and measurement surveys are conducted against protocols. Top-down and bottom-up emission calculations are closely assessed by the auditor (verifier) to be highly reproducible.

All verifiers or "MiQ Auditors" are trained to and accredited to the MiQ Standards under which they are eligible to conduct an audit. MiQ auditors are not MiQ employees and have no financial relationship with MiQ. They are employees of third-party firms and are accredited by MiQ to audit against the MiQ standard. MiQ Auditors are subject matter experts (SMEs) and must retain credentials in methane management, natural gas operations, GHG accounting and compliance

[13] Methane Guiding Principles. (2019). Reducing Methane Emissions: Best Practice Guide. Retrieved from https://methaneguidingprinciples.org/best-practice-guides/

[14] American Petroleum Institute (API). Compendium of Greenhouse Gas Emission Methodologies for the Natural gas and Oil Industry, 2021. Retrieved from https://www.api.org/~/media/Files/Policy/ESG/GHG/2021-API-GHG-Compendium-110921.pdf

[15] Def: Reasonable assurance – Assessor is confident that their audit was sufficiently thorough to form a conclusion with a high level of certainty. Reasonable assurance is generally perceived to be more credible than limited assurance, thanks to a higher level of testing and evidence provided by the auditor. Assessment includes more extensive testing, including tests of controls, data verification, and evaluation of underlying assumptions and methods. Includes site visits to test data management processes and equipment.

auditing. MiQ Auditors must submit non-conflict corporate statements and are assessed to ensure they are not connected to the production of the emissions data, or any work-product that is assessed as part of the verification. These requirements are wholly consistent with 45V's requirements for verification, including:

- The verifier is unconflicted to the data, therefore has no financial interest in the outcome of report;
- The verifier is a subject matter expert and technically accredited to the program they are verifying against;
- The verifier is independent of the data collected.

5.3 Credible verification of emissions is a low-cost and achievable process

MiQ verifications are completed, on average, in ten weeks, despite the robust criteria required by the audit process. Small and large operators alike have undergone similar experiences. Over a dozen audit or verification firms/teams have been accredited to the MiQ standard and verification program which allows for scalability and avoids bottlenecks where verification is required.

The cost of verification works out to ~1/20 US cent per MMBTU ($0.0005/MMBtu) per asset or facility, which includes the cost of the verifier and the use of the registry. The cost of verification has not been reported to be a hinderance for any operators and is comparable to routine GHG emissions accounting already underway in most organizations.

Any revenue generated by the 45V tax credits will more than offset any additional costs of verification from the various upstream segments that might require an annual emissions certification process. For example, a blue or turquoise hydrogen facility earning the lowest tier tax credit under 45V ($0.60/ton H2) should expect to generate between $3.00-$4.00 per MMBtu of natural gas consumed (as fuel and feedstock). If all segments of the natural gas supply chain required verification of emissions, this would mean the burden of verification would represent <<0.1% of the revenue generated to produce clean hydrogen. This incentive should compel upstream operations that have not yet verified their emissions to engage in a formal measurement-informed emissions reporting and verification program.

6 THE USE OF CERTIFICATES AND REGISTRIES TO TRACK VERIFIED AND CREDIBLE EMISSIONS DATA MEET THE 45V CRITERIA FOR ENERGY ATTRIBUTE CERTIFICATES (EACS)

6.1 Registries are necessary to support emission claims and avoid double counting

Natural gas is a commodity that passes through several hands before reaching its end user. Emission claims that are tied to the production, processing, and handling of natural gas require a sophisticated tracking program. Registries are the answer to this emissions tracking need and some are currently designed to support emissions claims from each segment of the natural gas supply chain. Much like any other environmental attribute (i.e., kW of renewable energy, renewable fuels, or carbon credit) double counting of energy with verified emissions is a real risk, especially when gas trades hands or is bundled together from different sources.

The proposed 45V rule lays out several criteria for the use of certificates as EACs, and their associated registries, to meet the carbon accounting goals for hydrogen production. Consistent with the proposed rules, the following criteria should be met for any certificate and registry used to support the emissions accounting needs for natural gas feedstock or fuel use:

- The use of unique identifier numbers for each unit of energy, or MMBtu of natural gas, to avoid double counting of emission attributes.
- Details on the geographical provenance, facility name, and operator responsible for the verified emissions intensity for each MMBtu of natural gas
- Details on the supply chain segment (extraction/production, gathering & boosting, processing, transmission & storage) associated with the verified emissions intensity so that a complete supply chain intensity can be constructed and used as unique user-inputs for the calculation of a hydrogen footprint.
- Time stamps for each MMBtu of natural gas throughput. Due to the embedded storage component of the natural gas value chain and inherent time lag between production and usage, timestamps need not to be more granular than 1 month.
- Verified emission intensities for each MMBtu of natural gas determined at the asset level, and details on the measurement standard for which the intensities were calculated. Due to the stochastic nature and fat-tail distribution of methane emissions and the impact that a singular super-emitting event can have on an annual emissions inventory, methane intensities should be assigned on a 1year or rolling 12-month basis to avoid "cherry-picking" of higher performing months.
- Details and accreditation of the third-party verifier that conducted the emission verification.
- Registries must have the ability to issue, track, move, and ultimately retire certificates and their corresponding environmental attributes.
- Registries should have publicly available information on facilities names, locations, and dates of verifiable emissions, for ease of cross referencing the use of certificates.

One such registry currently in operation is the MIQ Registry as discussed below.

6.2 The MiQ Registry for methane emission attributes was designed to meet EAC criteria defined under 45V.

The MiQ Registry has been in operation since 2021, and to date is issuing certificates for over 20 percent of the natural gas market. These certificates have accompanied bilateral contracts, single trade agreements, as well as transactions on marketplace platforms[16] for natural gas with verified environmental attributes. The MiQ Registry is hosted by Evident[17], the operator of i-REC – the International Renewable Energy Credit non-profit Foundation. IREC has issued over 500 million certificates for over 200 gigawatts of renewable energy capacity, in 48 countries. With this leading expertise, coupled with our designers' extensive experience in the renewable fuels program (RFS), the MiQ Registry was built to meet the highest possible credentials of any renewable certificate

[16] https://www.trumarx.com/cg-hub
[17] https://evident.global/registries

market. Each certificate issued by the MiQ Registry contains detailed information unique to the MMBtu gas generated or handled, including (1) unique identification numbers, (2) geographical information including the state and geologic basin, name and operator of the facility, (3) timestamp to the month of generation, (4) raw emissions information including CH_4, CO_2 and N_2O intensities, and (5) additional attributes such as ESG certifications including the Equitable Origin certification and performance grade. This information can all be referenced in bilateral contracts and single trade agreements to ensure sufficient coupling with the physical gas as needed. All verified facilities and the valid period of their verification status may be found on a transparent dashboard (**Figure 5**) on the MiQ Registry, complete with unique details and geographical information (**Figure 6**) so that any user or purchaser of certificates can properly cross reference their information.

6.3 The MiQ registry was designed to be free, easy to use, and interoperable with other certificate programs, registries, and trading platforms.

Current gas-based hydrogen producers, along with other sustainable fuel producers, need ready access to multiple certificate programs, including RECs, renewable natural gas, and now natural gas, to calculate and generate well-to-gate carbon footprints for their products. The MiQ Registry is highly interoperable with other data platforms through Application Programming Interfaces (API) which allows for seamless, auditable, and retireable certificate transfers. Holding an account on the MiQ registry is free and accessible to incorporated entities or companies subject to vetting by a robust financial review process (KYC), similar to holding a bank account, and agreeing to the registry legal terms and conditions The MiQ Registry applies a familiar, user-friendly interface which allows account holders access to the certificates held in their account with specific attributes such as facility name, geography, supply chain segment, time stamp as well as emissions values (**Figure 7**). Following transactions into or out of a user's account, the account holder has full access to the history of those transactions, the dates, times, and recipients of those certificate transfers (**Figure 8**).

6.4 MiQ Registry issues retirement statements which may be used as verifiable evidence for foreground inputs into the GREET model

Finally, account holders may undertake retirement of each certificate upon usage, which is tracked and catalogued by the registry in the user's account (**Figure 9**). Each retirement results in the issuance of a unique retirement statement (**Figure 10** and **11**) which details the timestamp of issuance, retirement, environmental attributes of each certificate, the issuing facility, geography, supply chain segment, and retiring entity. This information can be utilized directly into GREET foreground data under user-specific inputs (**Figure 12**), and the retirement statements themselves can be shared with verifiers as evidence of these inputs

7 RECOMMENDATIONS FOR IMPLEMENTATION.

MiQ recommends that the Treasury, as supported by the DOE and EPA, allow the use of bespoke inputs for natural gas methane loss as foreground data into GREET towards the calculation of a carbon footprint of clean hydrogen. The Treasury must make a timeline clear in the final rule any changes or updates it plan to makes to GREET 45V or the PER process into the future, to create some certainty about the future application process and enable hydrogen producers to secure FID for new projects.

As demonstrated above, credible and verifiable emissions data are available today when applying measurement-informed standards which avoid cherry picking of emissions followed by robust third-party verification processes. To enable the use of bespoke emissions data from natural gas,

7.1 MiQ Recommends that the U.S. Treasury, supported by the DOE and EPA, **should officially accredit or recognize those (a) metrics/standards, (b) verification programs, and (c)certificate registries that meet the criteria for a credible and verifiable differentiated natural gas market.** The DOE, namely the FECM, has unique experience and familiarity with the methane issues from the natural gas sector and poised to implement such accreditations. There is a pre-existing model in the United States for this as the same has already been done for REC registries. **These criteria must include:**

7.2 The use of a **measurement-informed emissions reporting standard**.

7.2.1 Such a standard (or metric) must recognize top-down and bottom-up measurement-informed evaluation of emissions. This means that data from the source level (bottom up) and facility or asset level (top down) must be considered or reconciled in the accounting of total emissions. Examples of such standards include the OGMP 2.0 protocols, GTI Veritas protocols, and the MIQ Performance Standard. As an example, please see our standards on MiQ.org.

7.2.2 Such a standard (or metric) must represent a complete assessment of all emissions sources, all technologies, and all gas flow from an entire asset or facility (meaning all contiguous, commonly owned and operated equipment, not only a subset of equipment or wellpads or data based on pilot studies) to avoid cherry picking emissions.

7.3 The application of **third-party verification protocols** which match 45V requirements, including:

7.3.1 The third-party verifier is unconflicted to the data, therefore has no financial interest in the outcome of report

7.3.2 The third-party verifier is a subject matter expert and technically accredited to the standard they are verifying against

7.3.3 The third-party verifier is independent of the data collected.

7.4 The **use of registries** that provide services and information sufficient to issue, track, move, and ultimately retire certificates and their corresponding environmental attributes to prevent double counting, **consistent with the 45V requirements for EACs**. Such registries and certificates must include:

7.4.1 Unique identifier numbers for each unit of energy

7.4.2 Details on the geographical provenance, facility name, and operator responsible for the verified emissions intensity

7.4.3 Details on the supply chain segment sufficient to construct a supply chain intensity

7.4.4 Time stamps for each unit of energy throughput

7.4.5 Details of the third-party verifiers for each facility

7.4.6 Details of verified emissions intensities sufficient to support hydrogen producer verifiers to cross reference for inputs into carbon footprint calculations.

7.4.7 Retirement statements that can be used as credible and direct evidence for foreground inputs into GREET 45V and verified by a hydrogen production verifier.

7.5 PER Process

If the Treasury will not allow for direct-user inputs (i.e., project specific inputs) into GREET, now or at any time, then operators which can verify methane loss or GHG emissions for natural gas feedstock and fuel use may apply for a provisional emissions rate (PER). PER applications must use the same burden of proof for credible and verifiable natural gas emission estimates as would be required for calculations under GREET (see 7.1-7.3, above).

7.6 Optionality

MiQ feels strongly that optionality in terms of using project-specific (bespoke) inputs or the use of national or basin-specific inputs is unsatisfactory. Because of the arguments stated earlier regarding the problems inherent with the use of national or basin-specific inputs, MiQ feels strongly that only project-specific (bespoke) inputs should be allowed for consideration of the 45V tax credit.

From a policy perspective this optionality would create distortions concerning the congressional intent of the program. For example, an operator might have two facilities. One of these, Facility A, is a hypothetical low-emitting facility and the other, Facility B, emits at ultra-high levels. Under an optionality-driven system, the low-emitting Facility A could receive credits by utilizing project-specific data (reflecting low emissions), and Facility B would also get credits by utilizing the national average. That Facility B would be eligible to receive credits is an upending of the entire intent of the 45V policy. This scenario would result in the same perverse outcomes were basin-specific averages to be used. Under a project-specific (bespoke input) only system, Facility A would appropriately get credits, while Facility B would be unable to.

Figure 1. *Distribution of production asset-level methane loss rates (as allocated to the handing of natural gas using the NGSI methodology) from across the Permian basin using top-down measurement studies from Kairos Aerospace.*

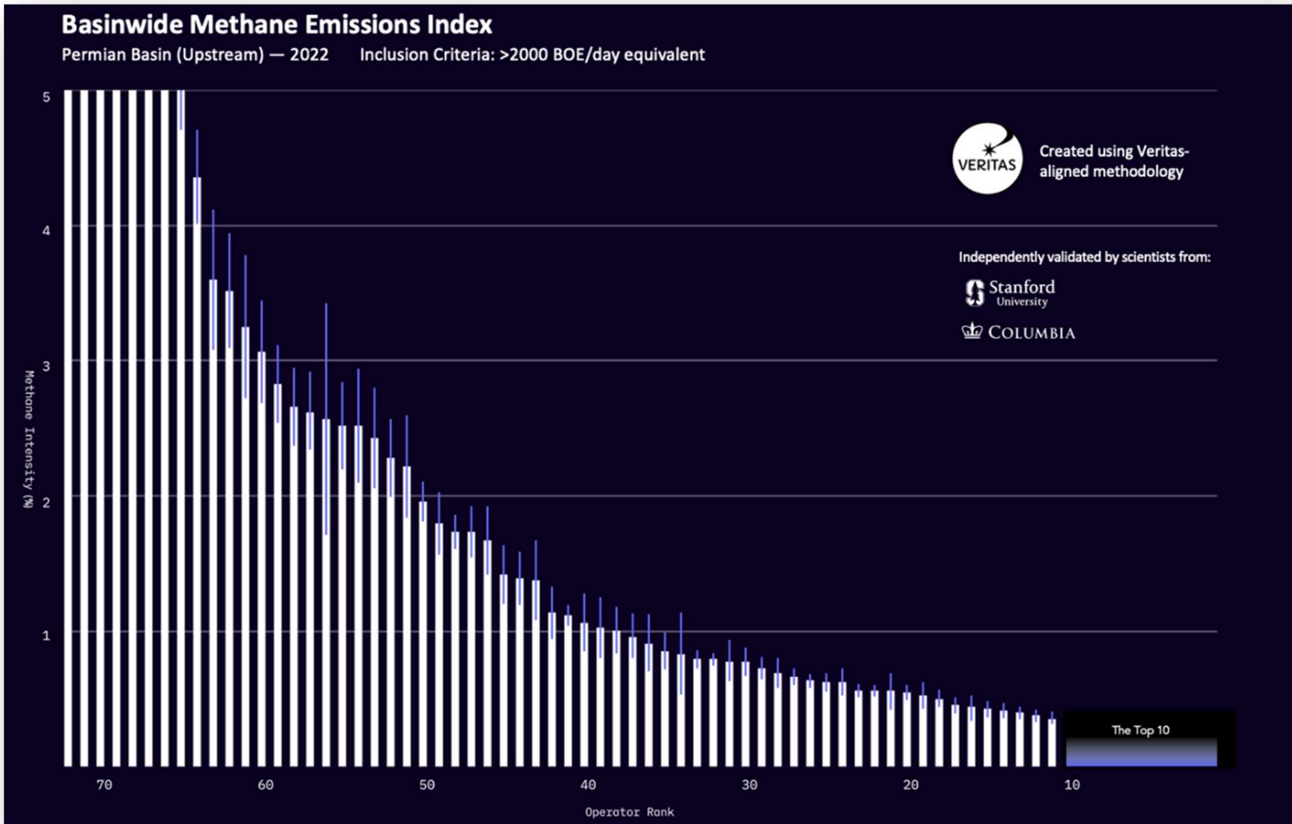

Figure 2. *Distribution of production asset-level methane loss rates (as allocated to the handing of natural gas using the NGSI methodology) from across the Permian basin using bottom-up GHGRP inventories.*

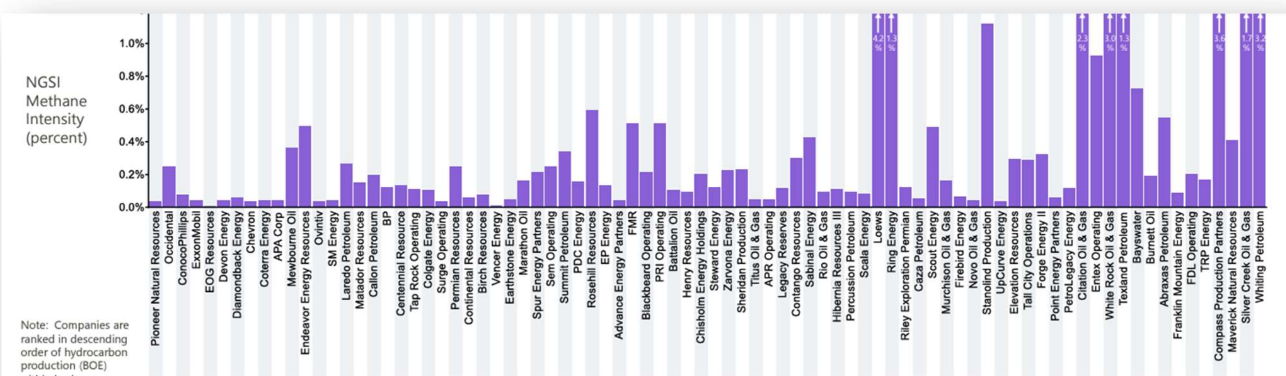

Figure 3. *Nationwide averages of methane loss from the production segment and complete natural gas supply chain (through transmission) from various studies and inventories.*

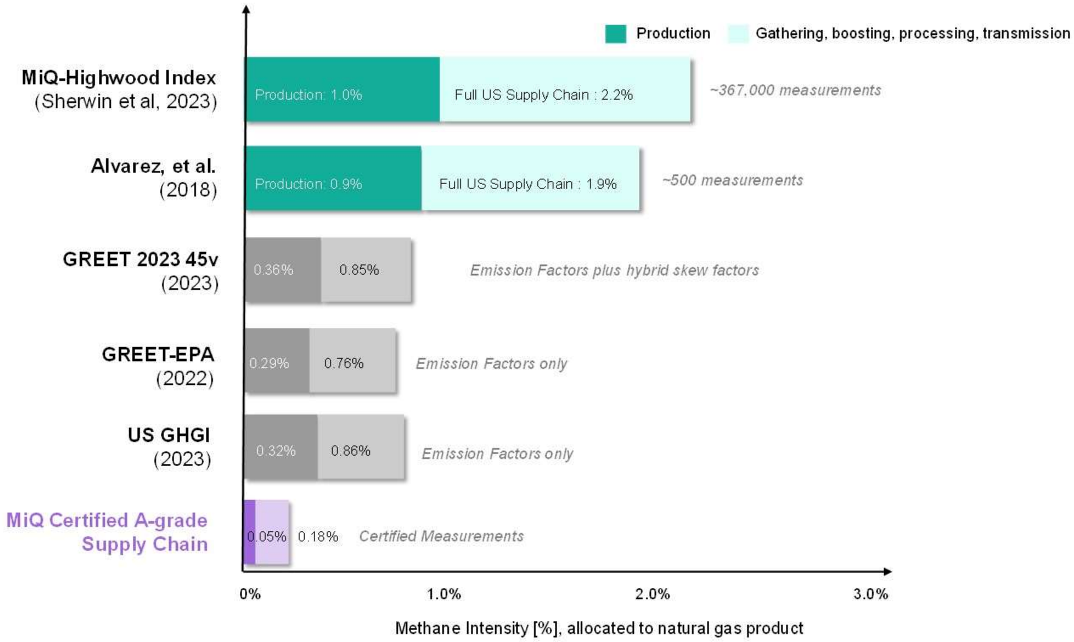

Figure 4. *Computed scenarios of carbon footprints (kgCO₂e/kgH₂) for hydrogen production by SMR using the GREET 2023 45v model and applying realistic methane loss estimates.*

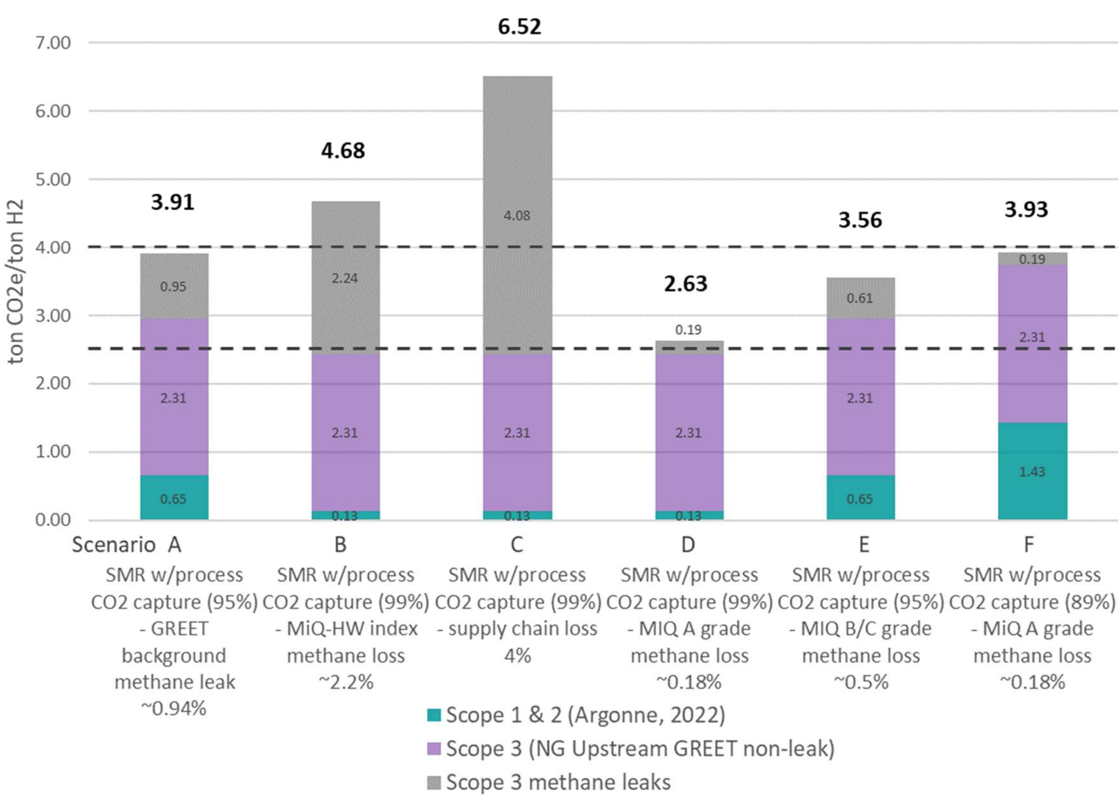

Table 1. *Realistic methane loss rates for verified or likely verified operations in the United States.*

Realistic Verified Segments in US (as of 2023)	MiQ Grade	Methane Loss (%)	Methane Intensity (g/MMBtu)
Production	A - C	0.05% - 0.2%	10 - 40
Gathering & Boosting	B - D	0.1% - 0.5%	20 - 100
Processing	A - B	0.05% - 0.1%	10 - 20
Transmission & Storage	B - C	0.1% - 0.2%	20 - 40

Figure 5. *Screenshot of Verified Facilities Dashboard on MiQ Registry (captured 1/25/2024, https://www.miqregistry.org/certifications)*

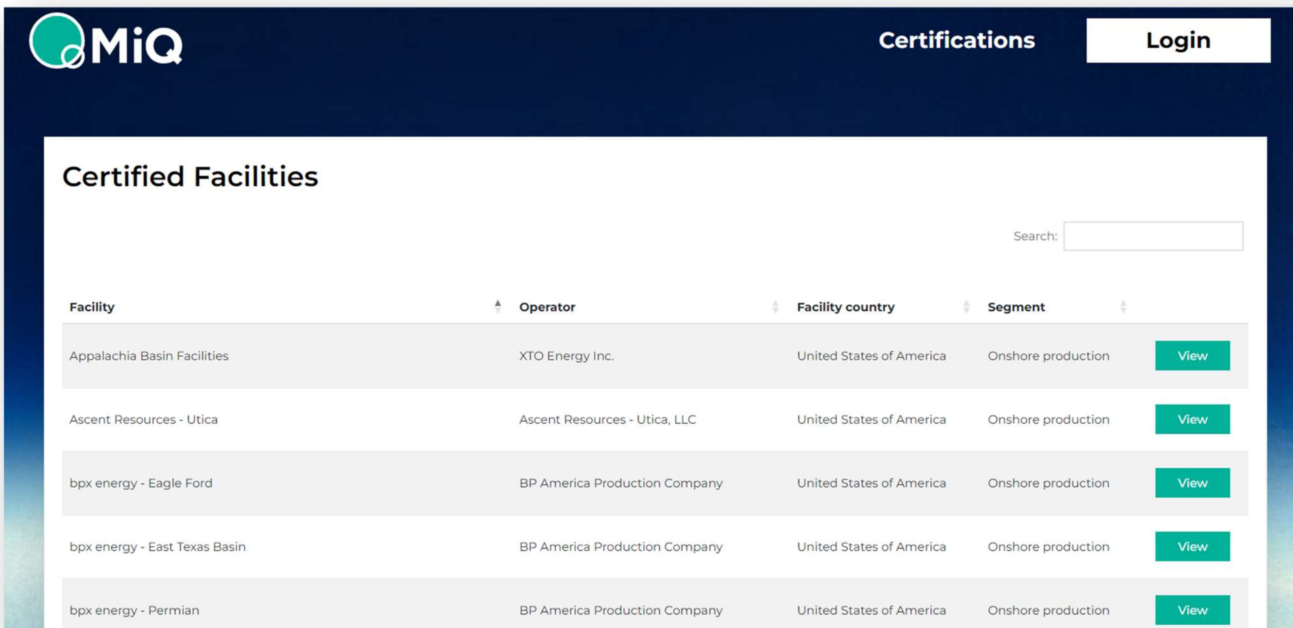

Figure 6. *Facility specific details for a verified operation on the MiQ Registry*

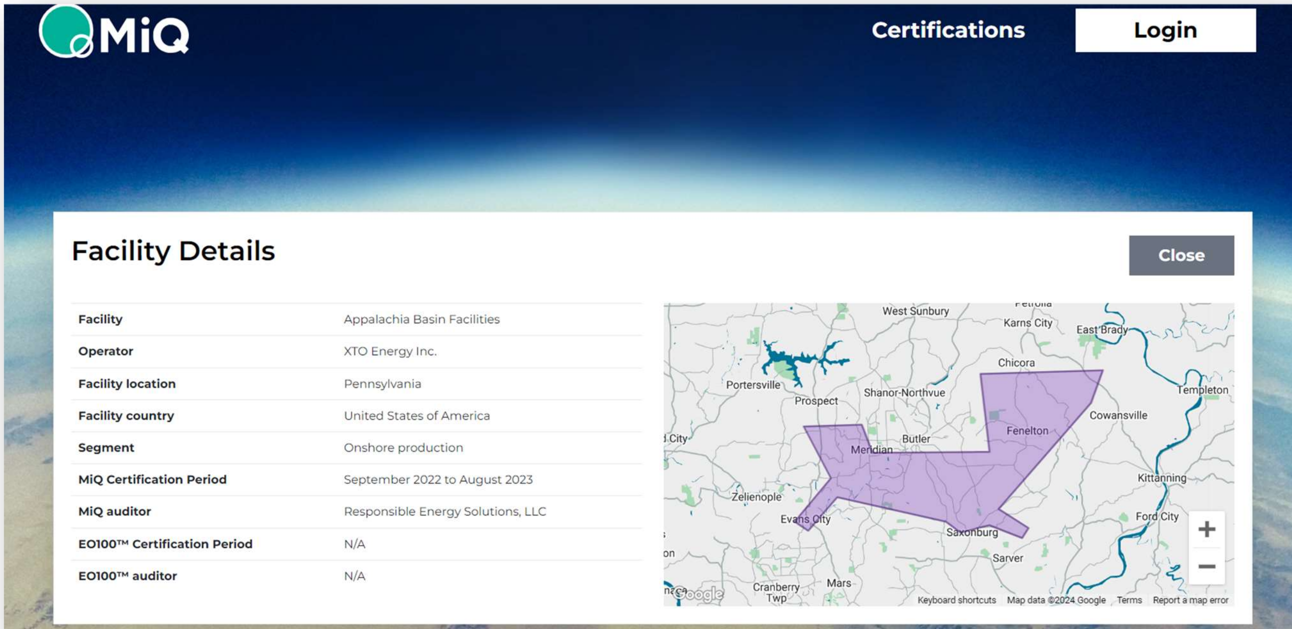

Figure 7. *Screenshot of MiQ Registry user account, illustrating various certificate holdings and details of their unique attributes.*

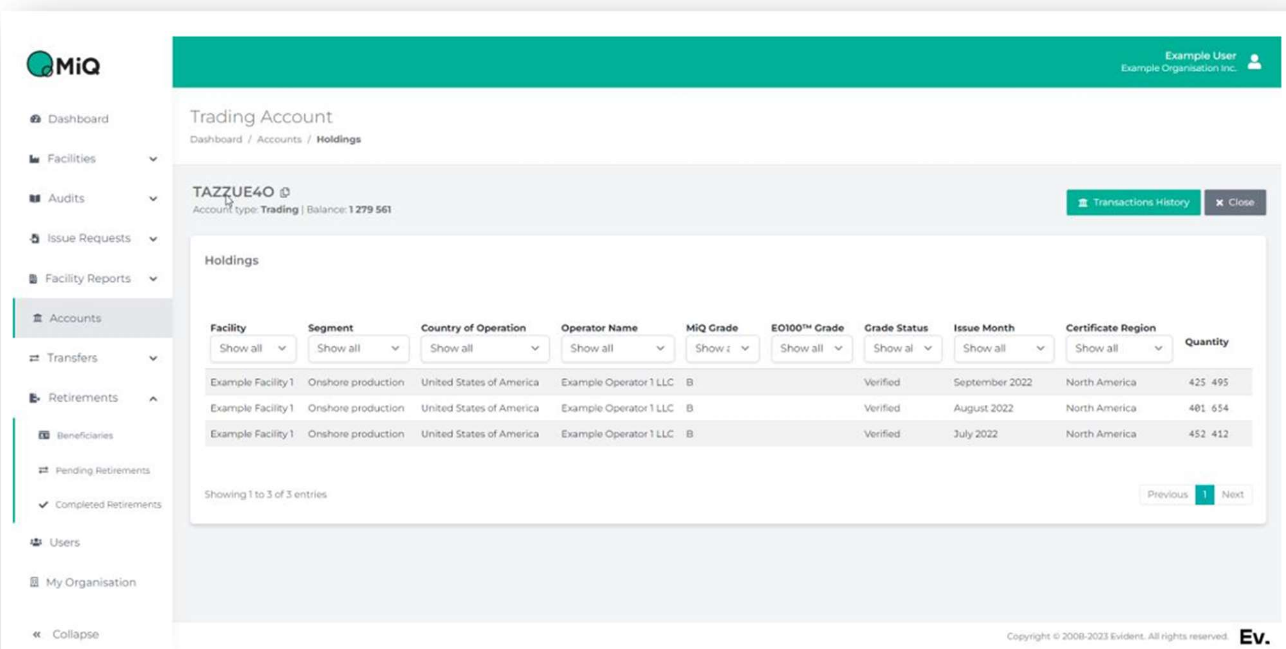

Figure 8. *Screenshot of MiQ Registry user account, illustrating history of transactions of certificates having taken place along with date of transaction and destination account.*

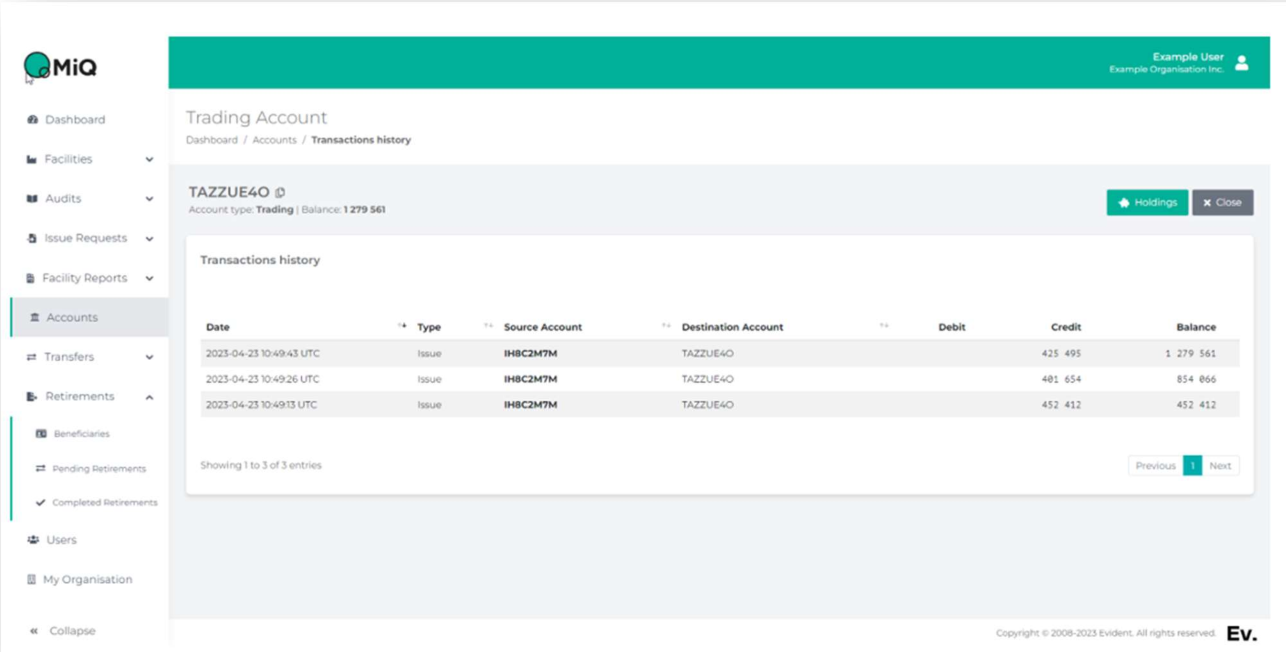

Figure 9. *Screenshot of MiQ Registry user account, illustrating ledger of certificates having been retired along with timestamps and link to retirement statements.*

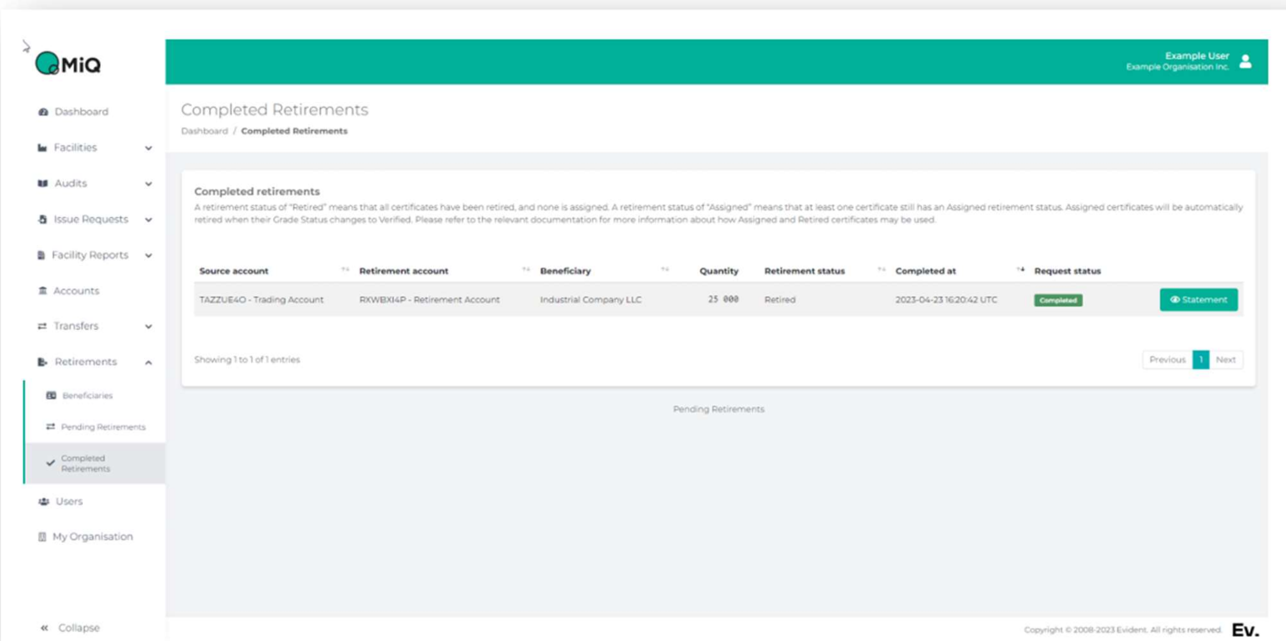

Figure 10 *– Example retirement statement issued by the registry and available to account holder.*

This statement was generated on 2023-04-21 14:11:29 UTC

Independently Certified Gas Retirement Statement

MiQ

This Retirement Statement confirms that

5 000

Certificates each representing 1 MMBtu (or 0.293 MWh) of certified natural gas have been Retired for the Beneficiary,

My First Beneficiary Inc.

for the purpose of

"consumption in 2022 at xyz facility"

for natural gas consumption located in

North America

These certificates were retired on behalf of the Beneficiary by

miqtesting.002+R7UAT-RAH01

on

21 April 2023 at 14:11:10 UTC

Statement Verification

This statement can be verified for authenticity on the MiQ digital registry. Use the QR code or copy the URL below to download a copy:
https://release.miqregistry.dev/pub/certificates/6oRJSTc6Ku0PvmSDlh98j2AKpngRzmqX15/21zwN45I=

Download access code: 83caf679

***Figure 11** – Example summary of retirement statements issued by the registry and available to account holder.*

This statement was generated on 2023-04-21 14:11:29 UTC

Breakdown of retired certificates

MiQ

This statement is proof of the secure and unique Retirement of the following Certificates for the named Beneficiary to be reported against consumption in the Certificate Region stated. Certificates are allocated to the named Beneficiary and cannot be further assigned to a third party.

The MiQ Standard and Certification program assures that the methane intensity of the Certified Gas represented by the MiQ certificates included on this Retirement Statement is at or below the level set out in the column 'MiQ Methane Intensity'. Such assurance is provided through a third-party independent audit combining monitoring, abatement measures and reconciliation of both top-down and bottom-up emission calculations for the entire facility.

Total Certificates: 5 000

Facility	Operator	Supply chain Segment	Country of Operation*	Issue Month	EO100 Grade	MiQ Grade	MiQ Methane Intensity (gCH4/ MMBtu)**	Certificate Region	Quantity	Certificate numbers	Status
MiQ Annual Offshore (2) (D4)	Registrant MiQ Annual (D4)	Offshore production	United Kingdom of Great Britain and Northern Ireland	July 2022		C	38.1	North America	1 000	0000-0000-9521-4965 - 0000-0000-9521-5964	Retired
MiQ Annual Offshore (2) (D4)	Registrant MiQ Annual (D4)	Offshore production	United Kingdom of Great Britain and Northern Ireland	June 2022		C	38.1	North America	2 000	0000-0000-9496-6199 - 0000-0000-9496-8198	Retired
MiQ Annual Offshore (2) (D4)	Registrant MiQ Annual (D4)	Offshore production	United Kingdom of Great Britain and Northern Ireland	May 2022		C	38.1	North America	2 000	0000-0000-9491-7439 - 0000-0000-9491-9438	Retired

* For the LNG Shipping supply-chain segment, Country of Operation is the country where the LNG was landed.

** Using a conversion factor of 52.514 mt/MMBtu

***Figure 12** – Screenshot of GREET input cells for user-defined methane emission loss estimates, and their associated supply chain segment categories of Production (Completion+Workover+Unloading+Venting), Gathering & Boosting, Processing, Transmission & Storage, and Distribution (Distribution not included in most Hydrogen WTG emission carbon footprint).*

4.3) CH4 leakage rate for each stage in conventional NG and shale gas pathways

3 | 1 -- Bottom-Up/Top-Down Hybrid; 2 -- EPA; 3 -- User defined

	Unit	Used in calculation: BU/TD Hybrid		User defined	
		Conventional NG	Shale gas	Conventional NG	Shale gas
Recovery - CH4 Leakage and Venting	vol. % of CH4 over NG throug	0.51%	0.51%	0.51%	0.51%
Recovery - Completion CH4 Venting	vol. % of CH4 over NG throug	0.00%	0.01%	0.00%	0.01%
Recovery - Workover CH4 Venting	vol. % of CH4 over NG throug	0.00%	0.00%	0.00%	0.00%
Recovery - Liquid Unloading CH4 Venting	vol. % of CH4 over NG throug	0.02%	0.02%	0.02%	0.02%
Well Equipment - CH4 Venting and Leakage	vol. % of CH4 over NG throug	0.33%	0.33%	0.33%	0.33%
Gathering and Boosting - CH4 Venting and Leakage	vol. % of CH4 over NG throug	0.15%	0.15%	0.15%	0.15%
Processing - CH4 Venting and Leakage	vol. % of CH4 over NG throug	0.03%	0.03%	0.03%	0.03%
Transmission and Storage - CH4 Venting and Leakage	vol. % of CH4 over NG throug	0.31%	0.31%	0.31%	0.31%
Distribution - CH4 Venting and Leakage	vol. % of CH4 over NG throug	0.09%	0.09%	0.09%	0.09%
Total	vol. % of CH4 over NG throug	0.94%	0.94%	0.94%	0.94%